

Diversification of rice-wheat cropping systems

for enhancing farmers' profit in Indo-Gangetic plains

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Rice-wheat cropping system has been the only source of livelihood for large sections of farmers in the Indo-Gangetic plains. This cropping system has shown source vulnerabilities to both climate change, and food and livelihood security. Demonstrations conducted under Farmer FIRST Programme in Palwal district of Haryana showed that diversification of rice-wheat cropping system in the Indo-Gangetic plains by adopting short duration basmati, wheat and summer mungbean can enhance farm profits besides conserving natural resources. Summer mungbean crop can be raised for grain and green manure for enriching soil health. The per day productivity of food grains has increased from 61.36 to 85.21 kg after introduction of mungbean as summer crop in the alternative cropping system.

Key words: Farmer FIRST Programme, Indo-Gangetic Plains, Rice-wheat cropping

RICE-wheat cropping system, being the major cropping system prevalent in Indo-Gangetic plains (IGP) across northern India, is posing great challenges for agricultural scientists, extension personnel and farming community, especially the small and marginal farmers. Farmers of IGP are facing severe climate changes affecting their crop growth and jeopardising their livelihoods. Major success of Green Revolution is attributed to these IGP. But rice-wheat system has resulted in consequences such as the problems of declining soil fertility, development of hard soil pan, adverse soil structure problems with high bulk density and low porosity and low crop productivity, mono-cropping and crop yield instability. To achieve sustainability in rice-wheat cropping systems of IGP, the existing cropping systems need to be improved with an additional legume crop for not only enhancing the soil structure and

fertility, but also ensuring farmers with additional incentive of income to accept and adopt the new cropping system.

An attempt has been made in the project villages of ICAR Farmer FIRST Programme (FFP) in Palwal, Haryana where the farmers were motivated to grow a summer legume crop to add value to rice-wheat cropping system for enhancing soil fertility and ensuring better soil structure and nutrient availability (by *in situ* incorporation of legume crop in crop fields, after one or two pickings). Here, an attempt has been to introduce short duration crop varieties with a view to enhance per day productivity in rice-wheat cropping system.

One of the key objectives was realisation of value addition to natural resources, farmers' income and saving days in cropping season through new short duration varieties of rice and wheat and growing an

additional legume crop of mungbean. The performance indicators, economics of crop varieties and innovative cropping system were compared. The farmers of the project villages Amarpur, Dadhota and Katesra of Palwal district of Haryana conducted these trials under the supervision of Scientists team of ICAR Farmers FIRST Programme. 150 farmers participated in trials to include mungbean as a summer crop to increase yields and profits in rice-wheat-mungbean cropping systems.

Comparison of performance of cropping systems

The usual pattern followed by farmers is to grow rice (Pusa Basmati 1121, a long duration variety of 143 days) in *kharif* and wheat (HD 2967) in *rabi* season. The problem of this cropping system lies in the fact that there is no time left for growing any summer crop as both these popular varieties are of long duration. No

green manuring is practiced by farmers. So soil fertility were reported declining.

Technology and implementation

As the major thrust of the program is to enhance farmers' profits, a special intervention was designed with the technical guidance of plant breeders to introduce short duration varieties of rice and wheat in this rice-wheat cropping system of IGP. Care was taken to identify crucial factors that enhance farmers' profits, assuring better management of natural resources, selection of most appropriate crop varieties and planning the crop rotation with the purpose of optimum utilisation of time and natural resources for maximizing farmers' incomes and profits.

Existing cropping pattern

The farmers were growing PB 1121, which is sown in the nursery by 8th June and then the rice seedlings were transplanted. They used to harvest before 25 to 31 October. Then after about 19-25 days wheat is sown by 15 November (Table 1).

Indeed, this is the best combination for the farmers and hence farmers were quite happy about crop yields. However, it appeared to the extension scientists' team that even the 'best can be made better' by careful introduction of short duration crop varieties, that can save time, resources and withstand the vagaries of climatic conditions.

Innovative cropping pattern

Since farmers were using long duration varieties, designing an innovative cropping system for IGP farmers has caught the attention of the scientific team to introduce short duration cereal crop varieties with the key aim of enhancing per day productivity, save on the number of days and utilize the saved days to grow another crop for enhancing farmers' profits and restore the soil health and fertility levels of IGP crop fields. In Table 2, special characteristics of new crop varieties are included.

Results of innovative cropping system

The results of the innovative

Table 1. Existing and innovative rice-wheat cropping system for IGP farmers

Crops	Varieties	Sowing dates	Harvesting date	Duration (days)
Rice	PB 1121	08 June, 2017	28 October, 2017	143
Wheat	HD 2967	15 November, 2017	05 April, 2018	142
Innovative Cropping system: Intervention of ICAR Farmer FIRST Programme				
Rice	PB 1509	11 June, 17	06 October, 2017	118
Wheat	HDCSW 18	26 October, 2017	23 March, 2018	149
Mungbean	Pusa Vishal	03 April, 2018	07 June, 2018	65

cropping system including the economics are presented in Table 3. In *Kharif* 2017, about 41 farmers opted for a short duration variety PB 1509 and could reap 38.60 q in 118 days (from 11th June to 6th October). The per day productivity was calculated at 32.71 kg for PB 1509 compared to only 27.38 kg of PB 1121. Although the cost of cultivation of PB 1509 was lower than that of PB 1121, the gross income was more as the market rate for PB 1121 was slightly higher. The gross income and net profit were marginally lower for PB 1509. The cost-benefit ratio of the two rice varieties stood at around 3. Real savings were in terms of number of cropping days saved and saving in costly inputs.

When compared to previous cropping pattern, about 25 days (nearly a month) were saved for farmers. Again, farmers could start the wheat sowing quite early thereby advancing the wheat sowing by nearly one month.

In *Rabi* 2017-18, about 15 farmers were persuaded to try a new variety HDCSW 18 especially suited for very early sowing. This wheat variety has a special characteristic of withstanding high temperatures at the time of early wheat sowing. The sowing of HDCSW 18 was done on 26th October 2017, about 25 days earlier to the usual pattern. As the sowing was advanced by nearly one month, harvesting was also done early by 23th March 2018, thereby amounting to short duration of only

Table 2. Characteristics of three crop varieties in innovative cropping system

Rice: Pusa Basmati 1509	Wheat: HD CSW 18	Mungbean: Pusa Vishal
• Short duration high yielding Basmati variety (25-30 days' earliness compared to popular Basmati rice varieties) • Highly Aromatic • Long Slender Grain • High Nutritional Value and Soft Texture. • Pusa Basmati 1509 can help save upto 5-6 irrigations (about 33% saving of irrigation water)	• Has special attributes of surviving in severe abiotic stress • Suited for cultivation with surface residue of preceding rice crop under zero-till situation • Resistant to high temperatures at seedling stage • Can escape high temperature at maturity due to early seed formation • Highly resistant to brown rust	• Resistant to mungbean yellow mosaic virus • It matures in 60-65 days in summer season • Synchronous in maturity • Attractive and green in colour

Table 3. Comparative economics of rice and wheat varieties

Indicators	Paddy		Wheat		Mungbean
	PB 1509	PB 1121	HDCSW 18	HD 2967	Pusa Vishal
Yield (q/ha)	38.60	39.15	54.16	48.25	10.50
Per day productivity (Kg)	32.71	26.63	42.31	33.98	15.91
Cost of cultivation (₹/ha)	38,650	39,550	34,802	34,500	20,451
Market rate (₹/q)	3,025	3,200	1,735	1,735	5,075
Gross income (₹/ha)	1,16,765	1,25,280	93,967.60	83,713.75	53,287.50
Net returns (₹/ha)	78,115	85,730	59,165.60	49,213.75	32,836.50
B:C ratio	1:3.02	1:3.17	1:2.70	1:2.43	1:2.61

149 days. The per day productivity was calculated at 36.35 kg for HDCSW 18, compared to 33.98 kg for HD 2967. As the yield of this variety was nearly 5.91 q more, the net profit earned was nearly ₹ 10,000 more than that of HD 2967. The cost-benefit ratios were compared at 1:2.70 for HDCSW 18 and 1:2.43 for HD 2967. The economic performance of both the cropping systems are compared in Table 4.

From rice-wheat cropping system the net income realized was ₹ 134,944.75 but from rice-wheat-mungbean the net income realized was ₹ 170,118.10. In terms of incomes realized, 26.06% increase was found from the cropping system of rice-wheat-mungbean compared to rice-wheat cropping system.

Uptake, benefit and spread

Accrued benefits

The benefits accrued from adopting this innovative cropping system are manifold. Through adoption of short duration cereal grain crops, expensive agricultural inputs were saved and so costs were reduced for farmers. Per day productivity has increased by adopting a summer mung crop, farmers could get protein-rich pulses for their food consumption, thereby ensuring nutrition security of IGP farmers.

With introduction of mungbean a legume crop in rice-wheat cropping system, crop diversification has occurred leading to soil fertility enrichment. As short duration varieties have some special characteristics with regard to climate change adaptation, the adverse consequences of climate change vulnerabilities could be escaped, especially, untimely rains at rice crop harvesting time, heavy temperatures at the time of wheat sowings and escaping westerly hot winds at the time of harvesting. Thus, this innovative rice-wheat cropping system suitably modified by including short duration cereal crop varieties, saving time, resources and adding a legume crop for both grains as well as for green manuring is definitely a blessing for IGP farmers.

Table 4. Comparative economics of the two cropping systems

Crops	Varieties	Cost of cultivation (₹/ha)	Yield (q/ha)	Market rate (₹/q)	Net Income (₹/ha)
Existing cropping system (Rice-Wheat)					
Rice	PB 1121	39,550	39.15	3200	85,730.00
Wheat	HD 2967	34,500	48.25	1735	49,213.75
Total	74,050			1,34,943.75	
Innovative Cropping System (Rice-Wheat-Mungbean) – Intervention of ICAR Farmer FIRST					
Rice	PB 1509	38,650	38.60	3025	78,115.00
Wheat	HDCSW 18	34,801	54.16	1735	59,166.60
Mungbean	Pusa Vishal	20,451	10.50	5075	32,836.50
Total	93,902		1,70,118.10		
Net income from Rice-Wheat:			₹ 1,34,944.75/ha.		
Net income from Rice-Wheat Mungbean:			₹ 1,70,118.10/ha		
Increase in net income			26.06%		

Table 5. Spread of diversified cropping system

Technology	No. of farmers covered	Uptake in next year (2018-19) in FFP cluster	Spread (%)
Short duration paddy-wheat-mungbean	15	28	86.66

Farmer-experimenters who tried this innovative cropping system understood how new agricultural technology could enhance their farm profits and so expressed desire to continue to adopt and get benefits.

Horizontal spread

The diversified cropping system demonstrated under FFP villages cluster has become popular in FFP village cluster. Table 5 shows that 28 farmers adopted the diversified cropping system in the next year on their own in FFP village cluster. Farmers of nearby villages also showed their interest and during 2019-20 it is expected to be adopted by a large number of farmers in and around the FFP cluster.

CONCLUSION

ICAR FFP has enhanced farm profits by introducing short duration cereal crop varieties in rice cropping system for IGP farmers. The real savings were in terms of higher yields, increased per day productivity, and reduced vulnerability of short duration wheat variety. As the harvesting was done in middle of March, the HDCSW 18 wheat crop escaped the brunt of high speed moisture-depleting hot westerly winds. It also resulted in timely sowing of summer mungbean and

helped farmers reap another 10.60 q of pulse gains.

As wheat was harvested quite early, by 23 March 2018, mungbean was sown by 3 April 2018 which yielded 10.60 q/ha. The per day productivity was calculated at 16.15 kg. The gross income was ₹ 53,287.50, and the net profit was ₹ 32,836.50. The cost-benefit ratio was reported 1:2.61. Another great saving is restoration of good soil structure, enrichment of soil fertility due to incorporation of mungbean crop into soil after picking of mungbean pods, as green manure.

Thus, per day incremental yields (5.33 kg were accrued from *kharif* rice, and 2.37 kg from *rabi* wheat and 16.15 kg from mungbean) were obtained by adopting the innovative cropping pattern using short duration varieties and saving crop days in each crop season. Thus, about 23.85 kg food grains (cereals and pulses) was obtained as an extra benefit through the practice of innovative cropping pattern for Indo-Gangetic Plains farmers.

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